

SONGS IN CONTIGUOUS POPULATIONS OF BLACK-CAPPED AND CAROLINA CHICKADEES IN PENNSYLVANIA

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The whistled songs of the very similar and closely related Black-capped Chickadee (*Parus atricapillus*) and the Carolina Chickadee (*P. carolinensis*) are generally regarded as quite distinct. In southeastern Pennsylvania, the ranges of these two largely allopatric species are contiguous, with the Blackcap occurring in the northern sector and the Carolina in the southern. In an attempt to learn more about the distribution of song types, and presumably of the species themselves, we played taped songs to territorial chickadees in the area over five breeding seasons (extreme dates 17 April to 2 June) from 1963 to 1969. The songs of responding chickadees were tape-recorded, and notes were made on the behavior of the birds. We have classified these responses on the basis of the types of songs and on the composition of the song bouts recorded at each site. This paper presents these data, with an analysis and discussion of the findings and their possible significance.

STUDY AND METHODS

The study area is a rectangle bounded by latitudes 39° 53' N and 40° 13' N and longitudes 75° 45' W and 76° W; the area is approximately 22.5 miles from north to south and 13.25 miles wide (Fig. 1). It includes portions of Berks, Chester, and Lancaster Counties, Pennsylvania, and was selected to include breeding ranges of both species. The area is rural in setting and ecologically rather homogeneous. The wooded areas in the southern part more generally consist of farm woodlots and other small patches. The northernmost one-sixth of the study area is comprised to a large extent of rather rough, wooded state game lands and a state park. The natural vegetation is almost entirely deciduous growth, with a few small coniferous plantations, particularly in the north. Altitude ranges from 230 feet to 1,071 feet.

We broadcast pre-recorded, typical songs of one or the other of the two species from a Uher 4000S recorder at 87 localities (Fig. 1). We selected areas that appeared appropriate for nesting chickadees. The songs of any responding chickadee were recorded on a Nagra III recorder through an AKG dynamic microphone in a 24-inch parabolic reflector; tape speed was 15 in per sec. Comments on the type of songs broadcast and of the behavior of birds were also recorded, and written notes were frequently made. A limited number of audio-spectrograms were made on a Kay Electric Company Sona-Graph, using the narrow band filter to obtain as accurate a determination of frequencies as possible. Our Blackcap songs were from birds recorded in Berkshire County, Massachusetts, and the Carolinas were from New Castle County, Delaware.

In most cases the songs first broadcast were those of the species expected to be found in an area. This was an arbitrary decision, but we felt that response would occur more likely by playing the "local" rather than the other species' songs. Secondary broadcasts of the songs of the other species were frequently made when no reply was received or to test the response of a bird that had started its reply. Altogether, 97 recordings were

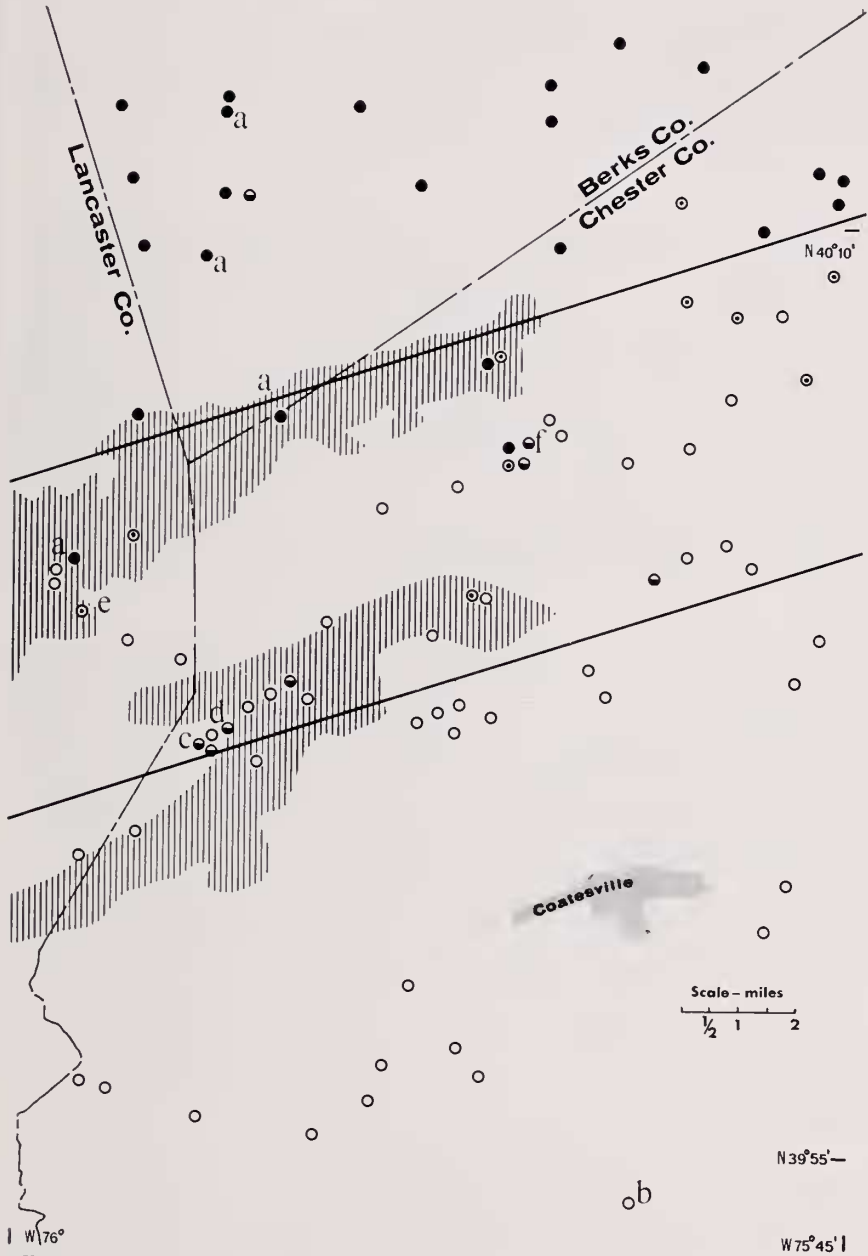


FIG. 1. Study area in three counties of southeastern Pennsylvania, showing northern, central, and southern segments (separated by heavier oblique lines), elevated areas (vertical slashing), and song types recorded (dot—Black-capped Chickadee songs only; half-black circle—Blackcap and Carolina songs; dotted circle—abnormal plus some Carolina songs; circle—Carolina songs only). Letters show text references.

made at the 87 locations. The ten repeated recordings were made in order to check further some unusual responses. Some of these rebroadcasts were one to two days after the original; in two or three cases the repeats were made two years later. All recordings made at one location are considered as one item in the analysis. Recordings were made from shortly after dawn until about noon.

CLASSIFICATION OF THE SONGS

A previous study of the songs of the Carolina Chickadee (Ward, 1966) showed wide variation in such parameters as number of notes per song, patterns of succession of notes in the higher and lower ranges of frequencies, and duration of notes. These variations were as great, or greater, among birds in Florida and in an area in tidewater Virginia, as among birds of regions closer to the Black-capped Chickadee's range. Every Carolina song recorded in that study included at least one note with a frequency (measured at its mid-point) higher than 4.7 kHz. The frequency at the mid-point seems to coincide closely with the pitch of the note, i.e. the frequency apparent to the ear. The high mid-point frequency in Carolina song is practically always distinguishable in the field from any frequencies heard in Blackcap song.

We have recorded songs of Black-capped Chickadees in Berkshire County and on Martha's Vineyard Island, Massachusetts, and in Monroe County and Centre County, Pennsylvania: we have listened to the songs in Alberta, British Columbia, California, Montana, New York, and Washington. In none of these places have we heard a chickadee song with a note pitched so high as to be confusable with the usual songs of the Carolinas. Our recordings do not show a note with a mid-point frequency above 4.3 kHz in Blackcap songs, and it is rarely above 4.0 kHz.

A three-noted song of the Black-capped Chickadee is frequently mentioned in the literature. We believe this refers to a fairly common form of the second note, in which occurs, in the middle of the note, a very short and sharp drop in the amplitude. Saunders (1946) says, "Frequently the second note has a slight waver in the middle, as if the bird sang *fee-beeyee* instead of *fee-bee*." The fact that there is no actual temporal break in sound is clear in the spectrograms that we have made of this form of note. These include songs of the species recorded by Dr. W. W. H. Gunn in Ontario, and which he kindly selected from his collection as showing this note form.

A considerable number of songs recorded by us contained frequencies in the range found in the Black-capped Chickadee, but included three, four, seven and eight notes. These we classify as distinctly abnormal, not safely attributable to birds of either species (Fig. 2).

Based on the above criteria, we have classified song types in our study into three categories: Blackcap, Carolina, and abnormal. Furthermore, we

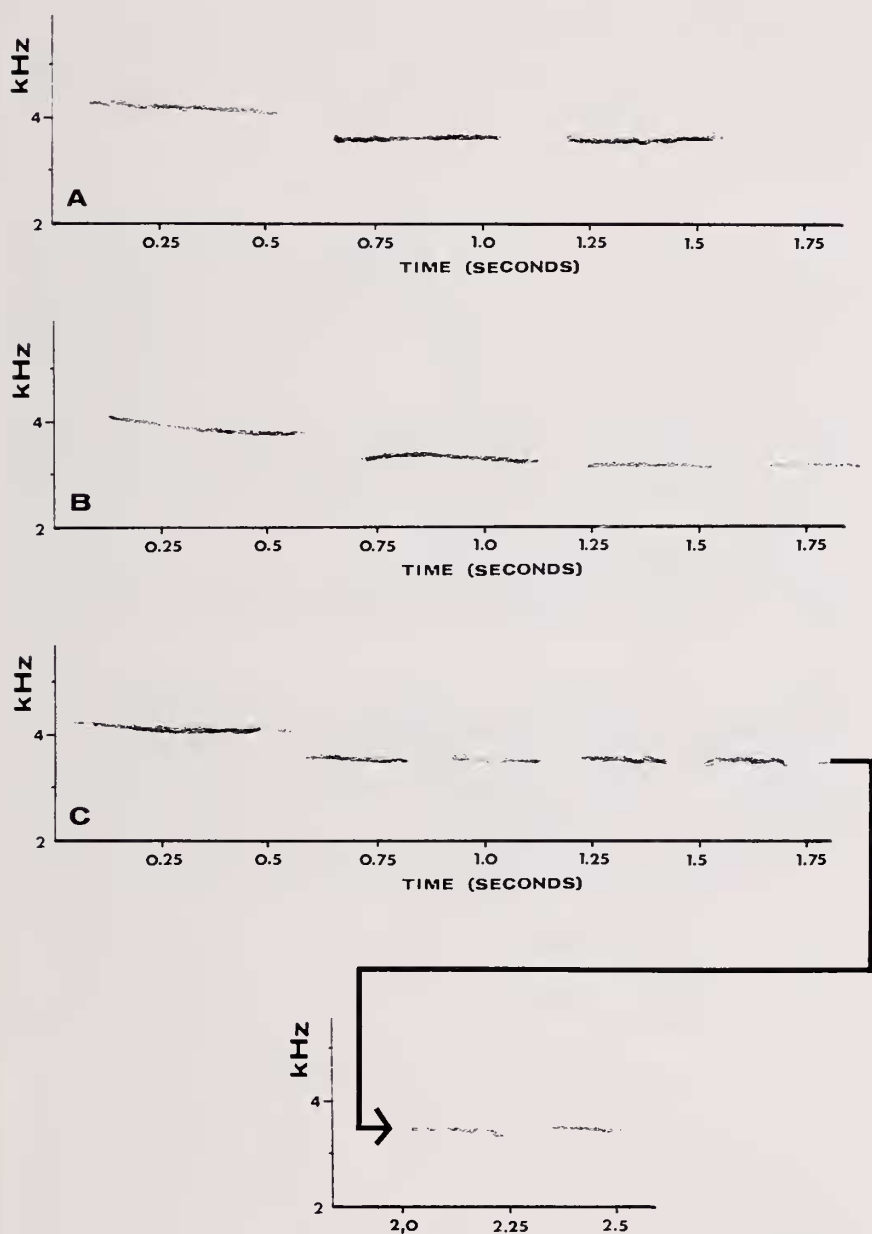


FIG. 2. Sonograms of abnormal chickadee songs from study area in southeastern Pennsylvania: A, three-noted song; B, four-noted song; and C, seven-noted song (shown in two parts). All of these songs are lower-pitched than those of Carolina Chickadees and have more notes than those of Blackcaps. Frequency (kHz) on vertical axis and time (sec) on horizontal axis.

have classified bouts of song into four categories: 1, consisting of only Blackcap songs; 2, consisting of Blackcap and Carolina songs (may include abnormal songs as well); 3, abnormal (may include Carolina songs as well); and 4, consisting of Carolina songs only.

RESULTS OF SONG PLAYBACK

We have plotted all of the 87 localities at which responses were recorded, to show the distribution of song types identified in the area (Fig. 1). Based on these responses, we find the study area divisible into three segments (Table 1): a northern one where Blackcap songs predominate; a central one in which the songs of both species are frequent and in which the abnormal songs are concentrated; and a southern one in which only Carolina songs were heard. The central segment includes all or major portions of Honeybrook, East and West Nantmeal, Wallace, and West Caln Townships in Chester County and Salisbury in Lancaster County. Prominent geological features of central segment are two east-west hogbacks, Welsh Mountain on the north and the Baron hills on the south (Fig. 1).

Before discussing the significance of the above findings, we would like to present some data on specific response to playbacks in the study area and elsewhere.

Response to playback by Carolina Chickadees south of the contact zone.—We tested for these responses in an area about twenty miles south of the study area, where we had never found indications of nesting Black-capped Chickadees in ten or more years experience. On 16 and 18 April 1970, we broadcast Blackcap songs, followed by two min of silence, then again broadcast and silence for two min. This procedure was repeated at six stations. On two alternate days, Carolina songs were substituted for the Blackcap broadcasts, in the same format of testing.

Only one recognizable reaction by chickadees to broadcasts of Blackcap

TABLE 1
DISTRIBUTION OF SONG TYPES IN THE STUDY AREA

Song types recorded	Segments of the study area		
	Northern	Central	Southern
Black-capped Chickadee (only)	19	4	0
Black-capped and Carolina Chickadee ¹	1	7	0
Abnormal ²	1	9	0
Carolina Chickadee (only)	0	22	24

¹ May include some abnormal song.

² May include some Carolina, but no normal Blackcap song.

song occurred. Two chickadees appeared after the second broadcast, one of which sang "faint, tentative, high-pitched, two-noted songs." A third broadcast brought these birds back and incited a faint reply. A fourth broadcast brought the birds back again but with no reply song. The broadcasts of Carolina song produced aggressive replies at four stations. These included continuing song, agonistic calls, and flight back and forth close to the recorder apparently in search for the intruder.

These findings suggest that in these Carolina Chickadees the reaction to song is primarily species-specific away from the zone of contact, even when the distance is only a score or so miles. From this response, we theorize that song is a species attribute of the Carolina and probably of the Blackcapped Chickadee, at least away from the areas of near or actual contiguity.

Inter-specific response to song playback.—At four locations (Fig. 1, a) in the study area, playbacks of Carolina songs brought in birds that responded only with Blackcap songs. These localities are in, or within, $4\frac{1}{2}$ mi of the central sector of the study area, where the songs of both species—as well as abnormal songs—were heard. At another locality (Fig. 1, b), broadcast of Blackcap songs brought in a bird that replied with the common four-noted Carolina song. This site is in the southern segment of the study area, approximately ten mi south of the nearest locality where Blackcap song was heard.

In and near Pigeon Swamp, Middlesex County, north-central New Jersey, we discovered one bird singing Carolina songs and three birds singing Blackcap songs (one of the latter including abnormal songs). One bird, singing only normal Blackcap songs, approached very closely on our playing of Carolina songs, and it continued singing Blackcap songs. From the bird's continued singing and excited flying back and forth, we assumed that it was responding to Carolina songs, in an attempt to drive the intruder from his territory.

From these observations, we conclude that as the ranges of these two species approach each other, some cognizance of the song of the opposite species appears to come into play. In other words, the two species may become responsive to both songs, rather than just their own.

Responding birds singing the songs of both species.—At eight localities (Fig. 1) in our Pennsylvania study area, we recorded single birds singing audio-spectrographically normal songs of both Black-capped (Fig. 3) and Carolina (Fig. 4) Chickadees. A few of these birds also included some abnormal songs in their performance, i.e. of the low Blackcap pitch but with three to eight notes. At ten localities (Fig. 1), single birds sang abnormal songs, in some cases mixed with Carolina but never with Blackcap songs (Fig. 2).

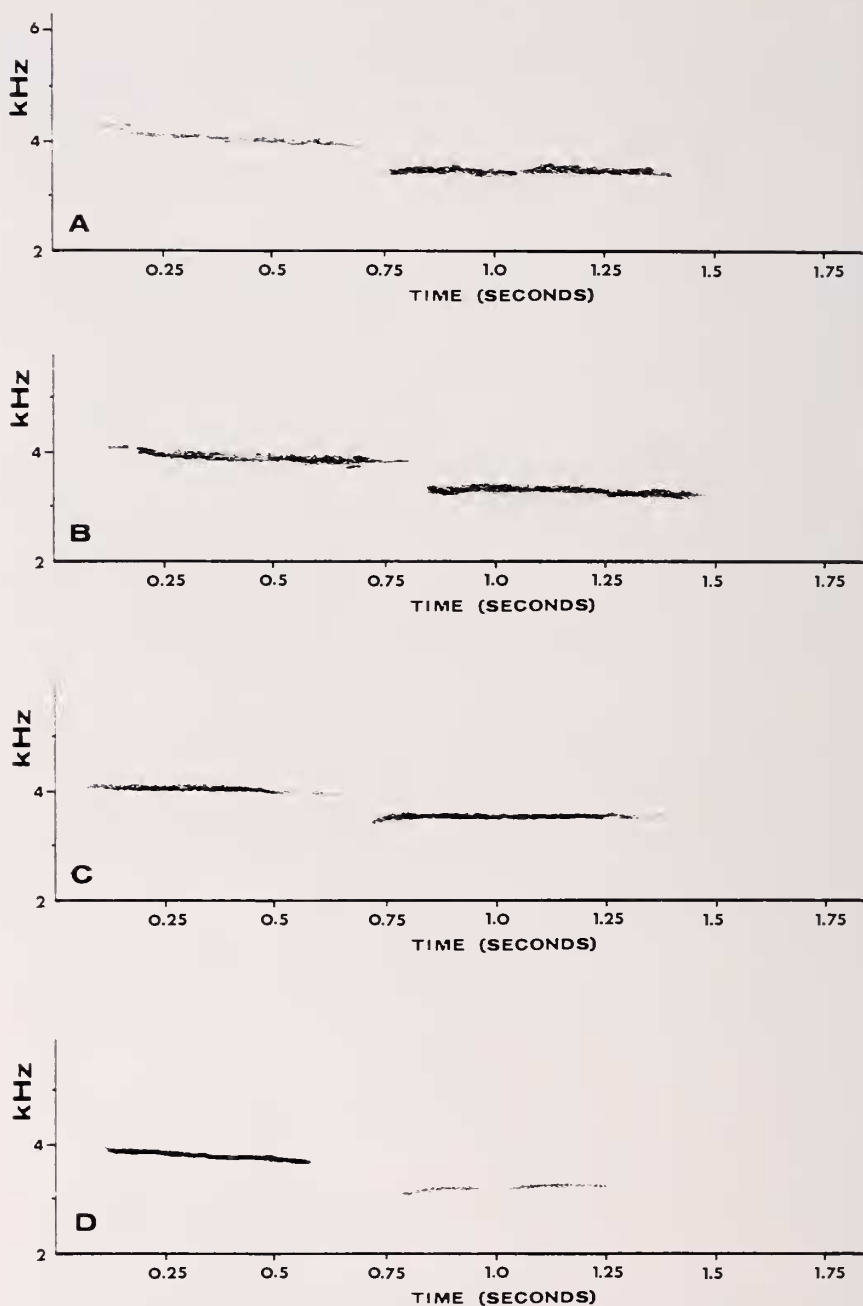


FIG. 3. Sonograms of Black-capped Chickadee songs: A, from Massachusetts; B, from Pocono Mountains, Pennsylvania; and C-D, from study area in southeastern Pennsylvania (these same individuals also sang typical Carolina songs, as shown in Fig. 4, C-D).

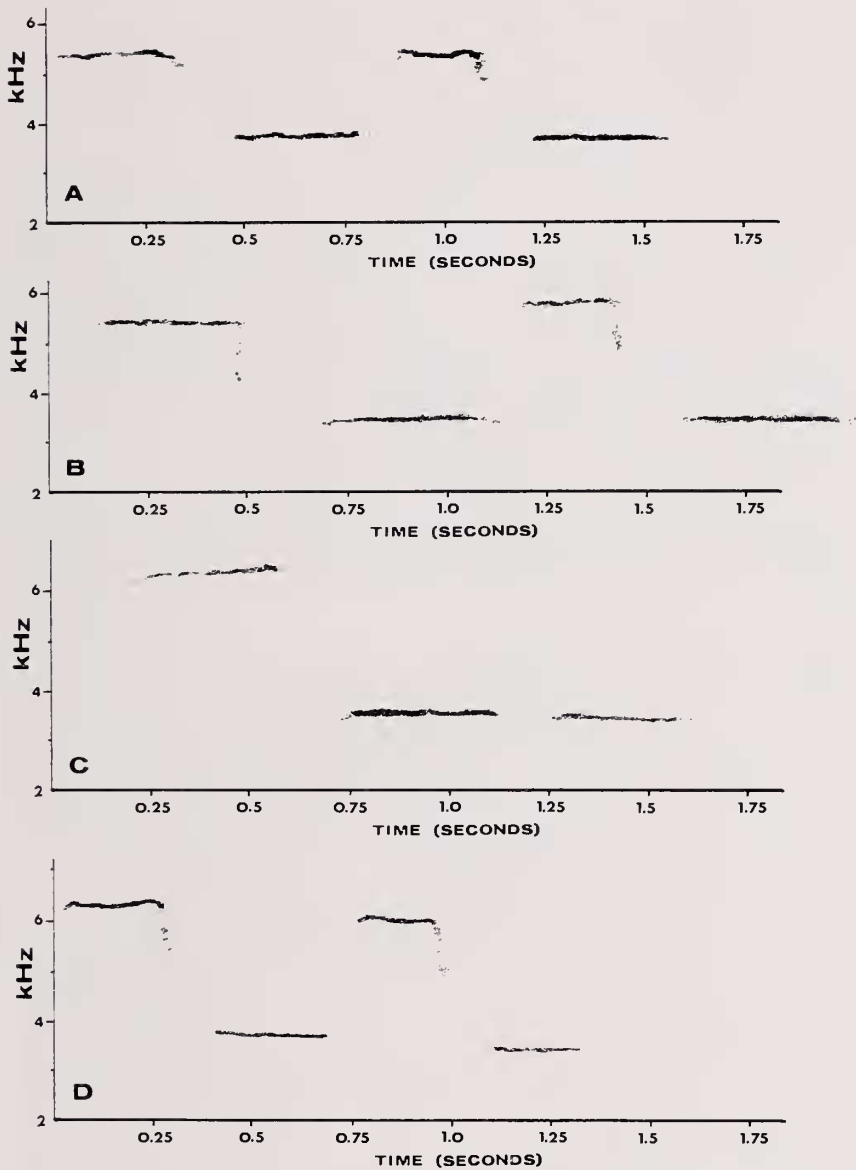


FIG. 4. Sonograms of Carolina Chickadee songs: A, from Delaware; B, from South Carolina; and C-D, from study area in southeastern Pennsylvania (these same individuals also sang typical Blackcap songs, as shown in Fig. 3, C-D).

In the birds that sang songs of both species, or of Carolina and abnormal types, we could find no evidence that the type of song broadcast has any influence on the replying types of songs. In nine such birds, five replied first in the idiom of the broadcast and four in the opposite.

At one location (Fig. 1, c) broadcast of Carolina songs attracted a bird that sang seven entirely typical Carolina songs, but without further broadcast it changed to a series of eleven normal Black-capped songs and four single-noted songs in the low pitch range. At the same location two days later, broadcast of Carolina songs again started Carolina reply, and again the bird changed to Blackcap songs without our further broadcasting.

At another locality (Fig. 1, d), a bird replied with normal Blackcap songs to a broadcast of Blackcap songs. We interrupted this with a broadcast of Carolina songs to which the bird replied with Carolina songs. It continued Carolina songs in spite of additional Blackcap broadcast.

A third example of this kind of reaction was provided at a locality (Fig. 1, e) at which a bird was incited to sing an abnormal song in response to broadcast of Blackcap songs. With no change in our broadcast the bird shifted to somewhat unusual Carolina songs. Eventually it moved away, but additional broadcast of Blackcap songs brought it back, singing the original abnormal song.

On the other hand, on two successive days at one location (Fig. 1, f) broadcast of Carolina songs attracted a bird that first replied with normal Blackcap songs and, without prompting, then changed to Carolina songs. The contemporaneously recorded comment on another occasion was, "This bird was started singing by our broadcasting Carolina song, and he started with the Black-capped song. Subsequently he sang Carolina, to some extent while we were broadcasting Black-capped song."

In May 1965, at Big Meadows, Shenandoah National Park, Virginia, our broadcast of Carolina songs brought in a pair of birds, one of which sang a series of Blackcap songs. The bird then changed to somewhat unusual Carolina songs, the shift occurring "quite a while after we had played back anything to him." After an extended period without any song from the bird, broadcast of Carolina songs again drew the pair back again, and one of them sang additional Blackcap songs. From time to time during this episode we heard another bird singing Carolina songs at a distance.

At Pigeon Swamp, New Jersey, a broadcast of Carolina songs started Blackcap reply. Eleven normal songs interspersed with seven three-noted songs in the Blackcap pitch range were recorded. We were preparing to leave when the bird changed to typical Carolina songs. We then recorded 15 more songs, all Carolina except for one normal Blackcap song.

DISCUSSION

The breeding ranges of the Black-capped and Carolina Chickadees are essentially contiguous from New Jersey to Kansas and in parts of the Appalachian Mountains. In some areas of the Midwest and southern Appalachians, respectively, there are gaps between the ranges of two species of a few miles (Brewer, 1963) or a few hundred feet in altitude (Tanner, 1952). In Kansas (Rising, 1968), other parts of the Midwest (Brewer, op. cit.), and in western Virginia (Johnston, 1971), the two forms meet and apparently hybridize—at least to some extent.

As already mentioned, the songs of the two species are generally distinct. In addition, the *dee-dee-dee* and *tsicka-dee-dee-dee* calls are usually distinguishable, those of the Blackcap being lower in pitch and given more slowly. However, the songs are the most distinctive, and these we have concentrated on in our study. In the Black-capped Chickadee, Dixon and Stefanski (1970) point out that songs are employed mainly by the male in maintenance of a claimed or occupied nesting territory—not, at least on a regular basis, to advertise for a mate. Brewer's (1961) assessment of the function of song in this species is similar to the above, as is that of Smith (1972) for the Carolina Chickadee.

The question of what happens to the songs of the two species in areas of contact has not been probed in detail, although authors such as Brewer (1963), Rising (1968), and Johnston (1971) draw attention to vocal anomalies in such areas. Our study has shown that anomalies also occur in the zone of presumed contact between these two species in our study area in southeastern Pennsylvania (and elsewhere). Basically, the anomalies are of two types: 1, intergradation, i.e. instances in which a bird sings songs that are both low-pitched (Blackcap trait) and composed of more than two syllables (Carolina trait); and 2, duality, i.e. instances in which a bird perfectly sings the songs of both Black-capped and Carolina Chickadees. A variant is where these two types are combined, i.e. a bird sings intergrade as well as the songs of both species or of the Carolina Chickadee.

In areas such as the Midwest (Brewer, 1963), Kansas (Rising, 1968), and Virginia (Johnston, 1971), anomalies in songs of these two species appear to result from hybridization. Such could also be the case in southeastern Pennsylvania, although we have no specimen data to assess this possibility. There is also a problem in equating vocal anomalies reported from hybrid zones by various workers—none of whom tape-recorded their birds—with the anomalies that we found. For example, Brewer's (1963) findings appear to differ from ours in two ways: 1, he reported that about half the birds in his zone of contact and hybridization sang *only* aberrant (= intergrade) songs; and 2, he reported no instance of a bird singing the songs of both

species. We found, on the other hand, that only about 21 percent of the birds in the presumed area of contact sang intergrade songs (Table 1), and of these several birds also sang Carolina songs. In addition, about 17 percent of the birds in this area of southeastern Pennsylvania sang the songs of both species. Precisely what the differences signify between our data and those of Brewer, we are unable to say. However, the differences do suggest that some caution is needed before blanketly ascribing the anomalies in songs to hybridization, at least in regards to our areas of investigation.

Although hybridization is perhaps the most likely cause for vocal anomalies in chickadee songs that we found (e.g. in southeastern Pennsylvania), it is not the only possible explanation. We would like to raise one other possibility, that being that the two species could be responding to contact by developing some degree of vocal convergence and mimicry. We admit that the evidence for this theory is scant, but we feel that it deserves some attention.

Earlier we cited several workers who reported that the main function of song in these two species is to defend a territory—rather than to attract a mate. In addition, Brewer (1963) has suggested that where the two species come in contact, they are interspecifically territorial. In fact, he found evidence in the Midwest that chickadees defended their territories against both species and any hybrids.

Given that the two species might be interspecifically territorial, one can envision that song might play an important role in this activity—at least in some areas. Furthermore, it would be conceivable that to facilitate vocal defense of territories, chickadees in an area of contact would mimic each other's songs and even converge to some degree, i.e. develop intergrade songs. Enhancing the supposition that mimicry and convergence might be occurring is the fact that such behavior would not interfere with mate selection, because the song is a repelling rather than an attracting agent.

Interestingly, in the hybrid zone in Virginia, Johnston (1971) took a bird that sang the songs of both species, and the specimen proved to be (at least mensurally) nearest the Carolina Chickadee. In the Great Smoky Mountains, Tanner (1952) also found a chickadee singing both songs; although he was unable to collect the bird, among other specimens from there he found no evidence of hybridization between the two species.

As a point of interest, a duality in song has also been found among interspecifically territorial species (and non-hybrid individuals) of meadowlarks (*Sturnella* spp.) by Lanyon (1957:23–26) and towhees (*Pipilo* spp.) by Marshall (1964) and Cody and Brown (1970). The latter authors and Cody (1970) provide discussions on vocal convergence (including mimicry), and we shall not elaborate on the subject further. Suffice to say, in raising mimicry/convergence as an alternative to hybridization to possibly explain anom-

alies in songs in our study area, we are mainly concerned with pointing out the need for a broader inquiry into the subject. As a matter of opinion, we feel that hybridization is indeed the most likely explanation for our results, but the issue is far from closed.

SUMMARY

Playback broadcasts were made of Black-capped and Carolina Chickadee songs during five breeding seasons in southeastern Pennsylvania. Responding chickadees were recorded at 87 different localities and their songs and song bouts were classified. We found a predominance of Blackcap song in the north of our study area and of Carolina song in the south; birds in the central segment sang songs of both species and sometimes songs that were abnormal in some way. We discuss two explanations for the situation in the central segment: one, the songs may reflect interbreeding; two, the two species may be interspecifically territorial in the area of contact, with individuals giving both species' and abnormal songs in defense of their territories.

ACKNOWLEDGMENTS

We wish to thank Charles C. Sibley for suggesting this investigation in our area and John Hubbard for valuable suggestions and for comments on the various drafts of this paper. The Laboratory of Ornithology of Cornell University provided the Nagra recorder and Crawford H. Greenewalt made available his Sona-Graph for our use.

LITERATURE CITED

- BREWER, R. 1961. Comparative notes on the life history of the Carolina Chickadee. *Wilson Bull.*, 73:348-373.
- BREWER, R. 1963. Reproductive relationships of Black-capped and Carolina Chickadees. *Auk*, 80:9-47.
- CODY, M. L. 1969. Convergent characteristics in sympatric species: a possible relation to interspecific competition and aggression. *Condor*, 71:222-239.
- CODY, M. L., AND J. H. BROWN. 1970. Character convergence in Mexican finches. *Evolution*, 24:304-310.
- DIXON, K. L., AND R. A. STEFANSKI. 1970. An appraisal of the song of the Black-capped Chickadee. *Wilson Bull.*, 82:53-62.
- JOHNSTON, D. W. 1971. Ecological aspects of hybridizing chickadees (*Parus*) in Virginia. *Amer. Midland Nat.*, 85:124-134.
- LANYON, W. E. 1957. The comparative biology of the meadowlarks (*Sturnella*) in Wisconsin. *Publ. Nuttall Ornithol. Club No. 1*.
- MARSHALL, J. T. 1964. Voice in communication and relationships among brown towhees. *Condor*, 66:345-356.
- RISING, J. R. 1968. A multivariant assessment of interbreeding between the chickadees, *Parus atricapillus* and *P. carolinensis*. *Systematic Zoology*, 17:160-169.
- SAUNDERS, A. A. 1946. In A. C. Bent, Life histories of North American jays, crows and titmice. *U.S. Nat. Mus. Bull.*, 191:332.
- SMITH, S. T. 1972. Communications and other social behavior in *Parus carolinensis*. *Publ. Nuttall Ornith. Club No. 11*, p. 33.

- TANNER, J. T. 1952. Black-capped and Carolina Chickadees in the southern Appalachian mountains. *Auk*, 69:407-424.
- WARD, R. 1966. Regional variation in the song of the Carolina Chickadee. *Living Bird*, 5:127-150.

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